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PROJECT RECORD

USING HEAT FOR SAGEBRUSH CONTROL

ED&T 2168
THERMAL BRUSH CONTROL

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U.S. Department of Agriculture
Forest Service
Equipment Development Center
Missoula, Montana

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ABSTRACT

Thermal equipment was tested on a sagebrush covered rangeland near Missoula, Montana, in May and August 1971. Although the results are not yet conclusive, indications are that sagebrush and certain other grassland invaders can be killed with blasts of hot air. More tests are planned with improved equipment to test the concept further and to establish production rates.

INTRODUCTION

In 1971, the Missoula Equipment Development Center began to investigate the possibility of eradicating sagebrush with heat. The Sawtooth National Forest, Intermountain Region, had used a propane agricultural burner for sagebrush control with promising results. Because the results were promising and because there is a growing need for sagebrush control methods without adverse environmental impact, this Center was assigned project 2168 - Brush Burner.

Initial investigation revealed that little is known about the effect of heat on vegetation. The effect of fire on vegetation has been the prime concern of research. With the intention of keeping the temperature below the ignition point to avoid wildfire and smoke pollution, field experiments were begun to determine: (1) the temperature ranges to work within, (2) the duration of treatment, and (3) the type of equipment required.

The project was continued in FY 1972 under a new title, Thermal Brush Control. This reflected the growing belief that heat, without actual combustion, can kill sagebrush.

This project record covers the work done since our last report to the Range Seeding Equipment Committee in February 1971. Also included are preliminary conclusions and recommendations for work beyond FY 1972.

METHODS

Preparation

Initial investigative work revealed no data concerning the effect of heat on sagebrush. However, the Northern Forest Fire Laboratory in Missoula noted: (1) that most plants can be killed if the protoplasm is raised to about 140° F. and (2) if flame was kept out of range plants, under average conditions air temperatures up to about 800° F. could be used without igniting dried grasses. With these two parameters in mind, equipment was designed and fabricated to test the concept of thermal brush control (fig. 1). A propane burner head and directional air control vanes were attached to a mist blower. This equipment moved about 2,800 cubic feet per minute (cfm) of air at a nozzle velocity of approximately 11,400 feet per minute, or 130 miles per hour. The burner used 16 gallons of propane per hour. The equipment was assembled for a low-cost test of the hot air concept and to serve as a prototype model to gather information for future designs. Open flame extended about 3 feet from the burner and caution was necessary to keep the flame from the plants during testing. The thermal equipment was mounted on a 1-1/2 ton stakeside truck for the initial spring testing. For the summer testing, several slight equipment modifications were made, including a smaller propane tank, which permitted the use of a 3/4-ton pickup truck.

The Center entered into an agreement with the Bureau of Land Management, Missoula District, to experiment on BLM lands, which provide the closest suitable stands of sagebrush. The BLM assigned a range conservationist and a wildlife biologist to work on the project. BLM help has been invaluable.

Field Tests

Spring Test

The test site is at an elevation of 5,100 feet above sea level. There was no snow after late April 1971, but soft roads and wet ground delayed testing until May 3. Big sage (*Artemisia tridentata*), which was the only sagebrush species found on the site, had broken dormancy and the leaves were green and succulent. At this time of the year, sagebrush has a leaf moisture content of 200 percent or greater, and stemwood moisture might be up to 160 percent. Other plants on the open sagebrush ridge included both rough and Idaho fescue, needle grass, wheat grass, a variety of forbs, bitterbrush, serviceberry, and small ponderosa pine and Douglas-fir invaders.

The grass and forbs were all green and growing. Ground cover was around 80 percent and exposed grasses were about 3 inches high. Taller grasses and litter were only found where protected by sagebrush. With the site

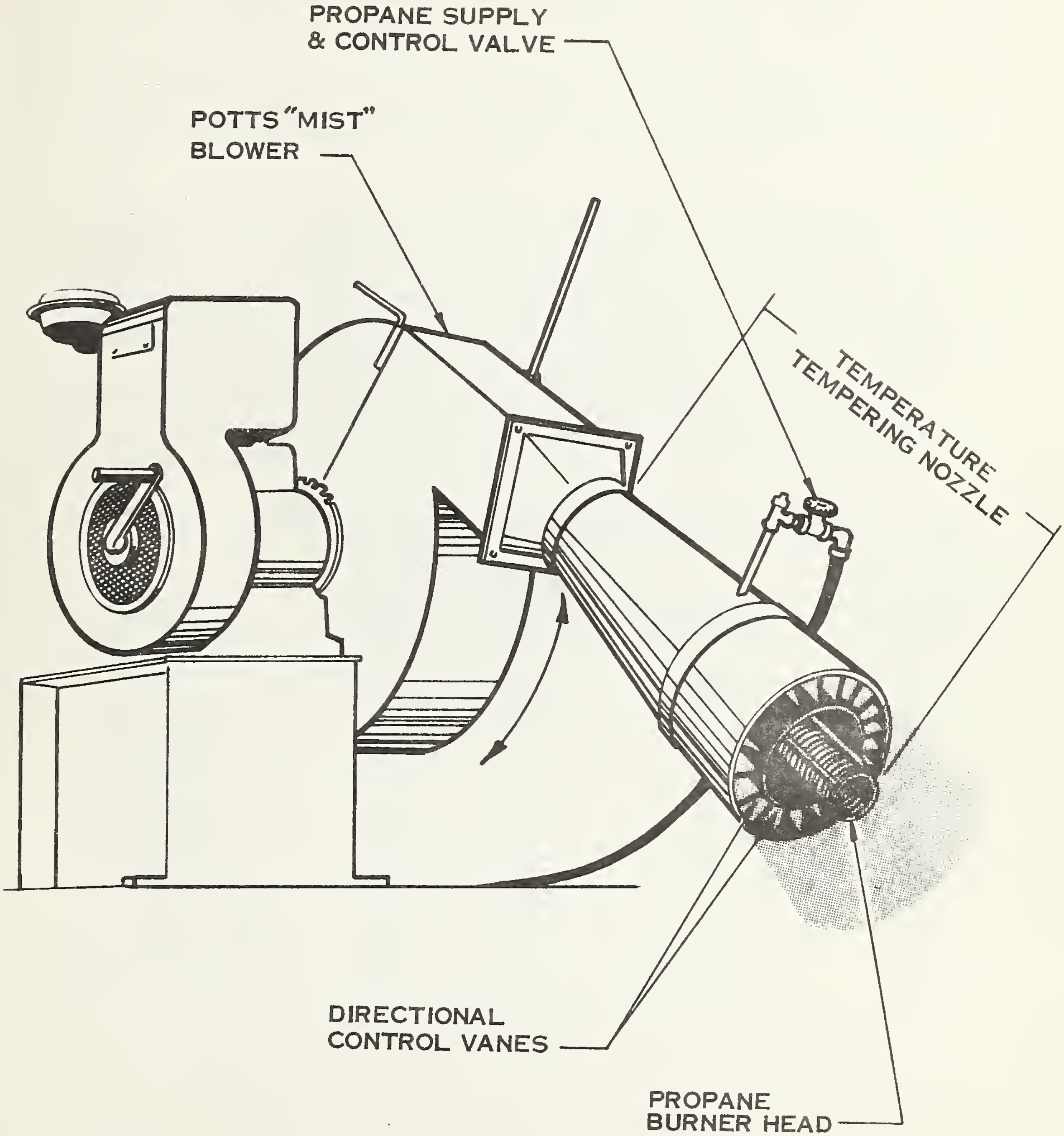

FIG. I — SAGEBRUSH THERMAL TREATMENT EQUIPMENT

green and still wet with standing snow-melt water in some areas, timing appeared right for safe testing. The afternoon temperature was between 50° F. and 60° F. Relative humidity was about 75 percent.

Although the primary goal in the testing phase was to observe the effect of heat on sagebrush, agricultural burning equipment similar to that used on the Sawtooth National Forest was also tried. The nozzle tested used 36 gallons of propane an hour and extended the flame out more than 4 feet. This burner head was mounted on a movable boom which was secured to the bed of a 1-1/2 ton truck. Several strips of sagebrush (each about 4 feet by 200 feet) were treated with the truck moving at 2 mph.

The Center's prototype equipment was not used to treat strips during the spring test. To determine proper temperature settings and duration of treatment, 12 individual plants were treated at separate locations with the truck stopped. Duration of treatment varied from 1 minute to 12 minutes and 40 seconds. Distance from burner head to plant varied from 4.5 feet to 8.0 feet (Table 1). At 4 feet from the head, air temperature was as high as 400° F. At 8 feet the temperature dropped to approximately 270° F. Six of the 12 plants treated were sagebrush. The other plants were treated to determine the effect of heat on the associated vegetation.

Table 1.--Individual plants treated in spring test (May 3, 1971)

	Species	Plant size: Average height	Plant size: Average diameter	Duration of treatment	Distance from burner head to plant
		Feet	Feet	Seconds	Feet
1	Sagebrush	2.0	1.15	154	8.0
2	Sagebrush	2.5	2.8	101	7.0
3	Sagebrush	2.0	2.2	85	5.5
4	Sagebrush	1.4	1.1	160	7.0
5	Sagebrush	2.0	2.8	160	6.3
6	Sagebrush	1.7	1.1	405	5.3
7	Douglas-fir	3.0	2.0	160	5.0
8	Bitterbrush	1.0	1.2	60	7.0
10	Serviceberry	1.6	1.2	120	6.0
11	Ponderosa pine	1.9	.8	120	5.0
12	Bitterbrush	1.6	1.4	120	6.0
13	Rough fescue	.8	.6	115	4.5

The tests gave an indication of the reaction of range plants to heat treatment during spring growth. Plant food reserves are at a low point after winter dormancy, but cool, humid days and abundant soil moisture should help a plant recover from heat treatment. Test specimens were monitored for signs of life at 1-month intervals after the spring tests.

Summer Tests

When growing conditions were not as favorable, the heat treatment tests were repeated on August 24, 1971, at the same site. The agricultural propane burner was not tested at this time because of the high fire danger. Precipitation had been less than normal during the previous 2 months. Understory growth was abundant and grasses were cured. Afternoon temperatures were around 80° F., relative humidity varied between 15 and 20 percent, and wind speed averaged about 5 mph.

Although slight modifications had been made to the thermal equipment, the unit was basically the same as that used during the spring tests. The most significant difference was that the nozzle height was lower because the equipment was now on a 3/4-ton pickup truck, instead of the higher 1-1/2 ton stakeside. Being lower, the air stream had to be directed in a more horizontal plane to keep the flame out of the sagebrush canopy. Seventeen individual plants were treated. Table 2 lists the species treated and temperatures recorded in the plant canopy. Two strips, each 100 feet long, were also treated with the thermal equipment, one strip at a speed of 0.8 mph and the other at 0.4 mph.

Because of the extreme fire danger, thermal equipment was used with caution on cured fuels and fire equipment was on hand. There was no fuel ignition during the testing.

Table 2.--Individual plants treated in summer test (August 24, 1971)

Plant number	Plant species	Plant size: Average height	Plant size: Average diameter	Duration of treatment	Distance nozzle to plant		Temperature at plant crown
		Inches	Inches	Seconds	Feet	Inches	Degrees F.
20	Sagebrush	18	18	15	5	0	150
21	Sagebrush	18	18	90	6	8	300
22	Sagebrush	24	30	60	6	6	260
23	Sagebrush	18	18	60	12	0	160
24	Sagebrush	24	14	30	6	10	260
25	Sagebrush	18	18	30	10	8	160
26	Rabbitbrush	18	18	30	7	0	160
27	Rocky Mt. Juniper	30	24	30	7	0	210
28	Douglas-fir	36	24	30	6	7	220
29	Ponderosa pine	48	24	30	7	6	170
30	Sagebrush	14	18	60	7	0	235
31	Sagebrush	24	18	60	12	6	205
32	Sagebrush	24	14	15	7	0	170
33	Sagebrush	14	12	15	12	0	182
34	Sagebrush	14	24	15	6	0	126
35	Bitterbrush	18	14	30	6	6	135
36	Bitterbrush	18	40	60	8	0	210

RESULTS AND DISCUSSION

Spring Tests

While treating strips with an agricultural burner from a moving truck, the flame penetrated into the sagebrush crowns. The sagebrush and grass litter quickly ignited and fire began to move through the crowns where the sagebrush was dense. It was surprising that under the green and wet conditions that prevailed the fire spread very quickly. There was enough dead branch wood, old seed heads, and litter to carry a crown fire. Without prompt suppression action, wildfire would have resulted.

Some of the 12 individually treated plants in the spring tests showed effects immediately after the heat treatment. Those sagebrush plants that were treated for 2 minutes or more changed leaf color from silver green to silver during treatment. A wind training effect was also observed on sagebrush and on the conifers treated. The Douglas-fir and ponderosa pine needles also changed color during treatment. Both species lost their dark green needle color. Neither the bitterbrush, the serviceberry, nor the rough fescue underwent an observable change during treatment.

All 12 plants were observed at 1-month intervals through October. From the first followup visit (June), it appeared that the treated sagebrush plants were dead. Although most of the leaves were still on the plants, they were very brittle and crumbled when touched. By August, most of the leaves on the treated sagebrush plants were gone and the branch ends were brittle. By October the plants had lost many of their branches, probably knocked off by cattle. None of the sagebrush plants had any leaves when last observed. There was no observable resprouting from any of the treated sagebrush.

In October, a dye test was used to determine if any living cells remained in the stemwood of the sagebrush plants. Because of inexperience with the test, results were not conclusive; however, there was evidence that live cells were still present in the stemwood of the spring-treated sagebrush. Observation of these plants will continue in 1972.

The rough fescue plants growing under the sagebrush canopy showed an interesting response to heat treatment. Rough fescue was probably more abundant on this particular range prior to grazing, but invader range species are now numerous in the heavily grazed areas. However, under the protection of the sagebrush plants, the rough fescue survived, but its vigor appeared low, possibly because of the sagebrush competition. After the sagebrush plant was treated, the rough fescue responded and grew up through the skeleton of the sagebrush plant. The sagebrush plant continued to protect most of the understory grass from grazing. No adverse effect was observed on the associated grasses and forbs because of the heat treatment.

The Douglas-fir and ponderosa pine appeared to be the plants most susceptible to heat treatment of all those treated in the spring. Needle discoloration and severe wind training were seen during treatment. Followup visits showed a rapid disintegration of these plants. By October the needles were gone and mortality seemed assured.

The two browse species treated, serviceberry and bitterbrush, showed a response to heat treatment that was both interesting and promising. At the time of treatment both species had just begun to leaf out. No immediate effect could be seen on the juvenile leaves or on the woody branches. By July the leaves had dropped off, and resprouting had begun on both species. By October the old branches had begun to disintegrate and heavy resprouting had occurred in both species.

Summer Tests

Our observations of the effects of the spring tests indicated that duration of heat treatment could be greatly reduced and still cause mortality in sagebrush. As Table 2 shows, individual treatment was reduced to as low as 15 seconds per plant. Followup observations in September and October indicated that the shorter treatment in August was as effective as the longer spring treatments. Followup observations in 1972 will be necessary to confirm this.

An observation made during the October followup visit will probably influence the design of future thermal equipment. Plants up to 12 feet behind the target plant showed signs of mortality. This was especially pronounced in the conifers. This is an indication that under summer conditions the hot air stream may cause mortality in sagebrush up to about 15 feet from the nozzle and will also reach other sagebrush plants partially protected by surrounding plants or obstructions. If substantiated by further testing, this effect may prove to be an important feature of thermal treatment. Other sagebrush control methods, including chemical, mechanical and burning, frequently do not obtain 100 percent kill in the treated areas. Missed plants can mean that treatment will have to be repeated. With the rapid movement of hot air through all portions of the treated area, it may be possible to achieve 100 percent kill of all sagebrush in that area.

Results of the two strip treatments during the summer tests were inconclusive. A color change could be seen along the strip during followup visits. The treated leaves appeared to still be living but were less succulent than the adjacent untreated leaves. At 0.4 mph vehicle speed, a plant with a 12-inch crown received about 1.6 seconds of direct treatment. At 0.8 mph this plant would receive only 0.8 second of treatment. It is thought that the equipment used did not generate enough heat, nor did it move enough air to effectively kill sagebrush from a moving vehicle. If the system is to be effective, heat generation and air movement must be increased.

PLANS FOR THE REST OF FY 1972

Two types of thermal equipment will be tested this spring. Figure 2 shows modifications that will be made to the equipment used during the 1971 tests. This equipment is designed to further evaluate the low air volume-high air velocity approach to treating sagebrush. Three basic changes will be made: (1) a different directional control nozzle will be used to increase air dispersion, (2) a larger (30 gallons per hour) burning head will be used to increase temperature, and (3) the burning head will be turned to achieve better heat-air mixing. This equipment is designed to move 4,800 cfm at 15,400 feet per minute or 175 mph at the nozzle. A temperature of approximately 530° F. will be obtained at a point 3 feet from the burner head.

Figure 3 shows equipment that is now being fabricated to test a new concept--high air volume-low air velocity. Two 24-inch diameter propeller fans will be mounted on the end of the 1-1/2 ton flatbed truck. Each fan will move 7,000 cfm at about 4,000 feet per minute (45 mph) at the nozzle. A 30-gallon-per-hour head to produce 365° F. at 3 feet and a 70-gallon-per-hour head to produce 850° F. will be tried. The fans can be adjusted to treat various strip widths.

The two systems will be tested at the BLM test site this spring. Further testing is planned on the Sawtooth NF this fiscal year.

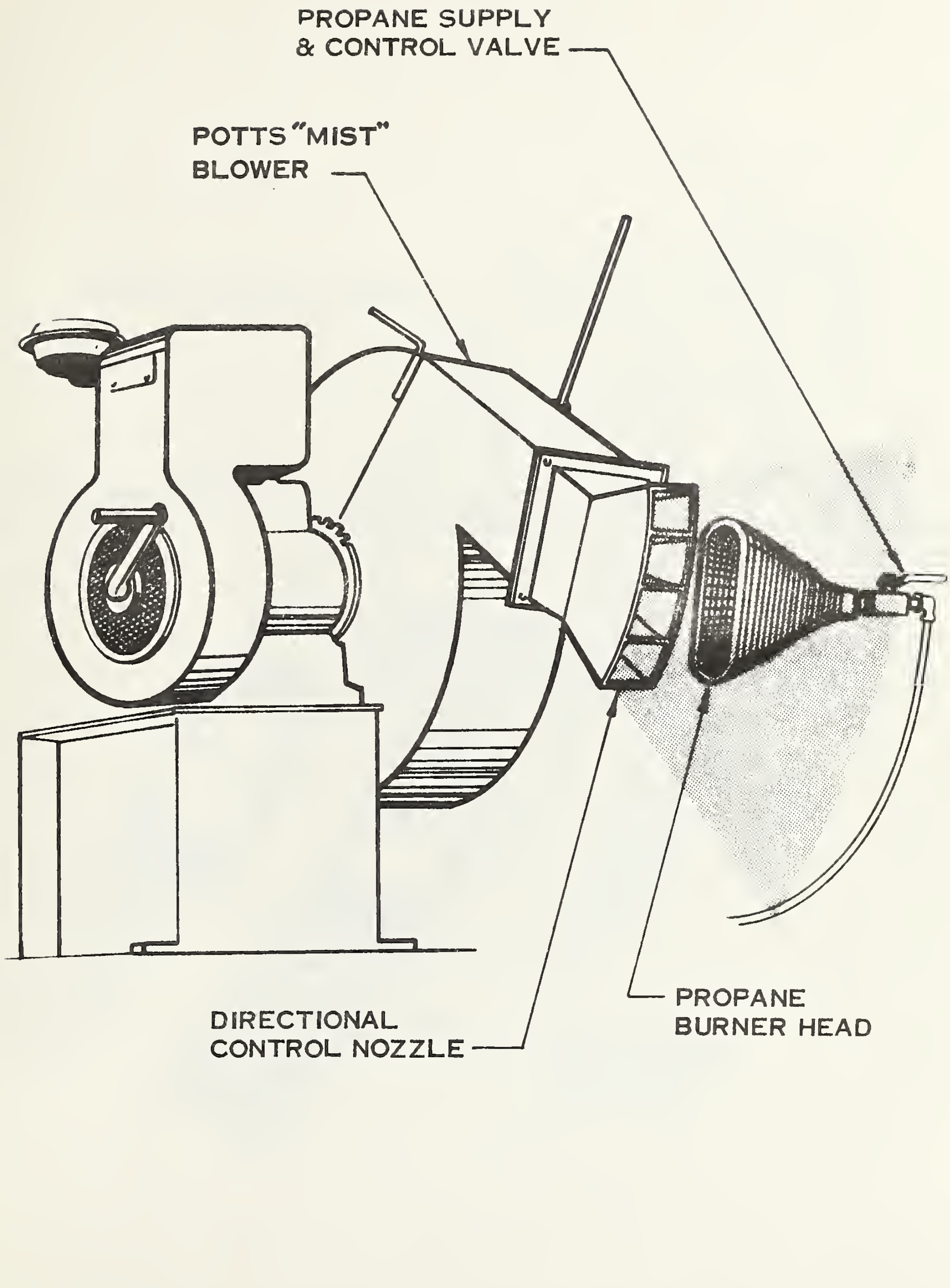

FIG. 2 — SAGEBRUSH THERMAL TREATMENT EQUIPMENT
(LOW AIR VOLUME—HIGH AIR VELOCITY)

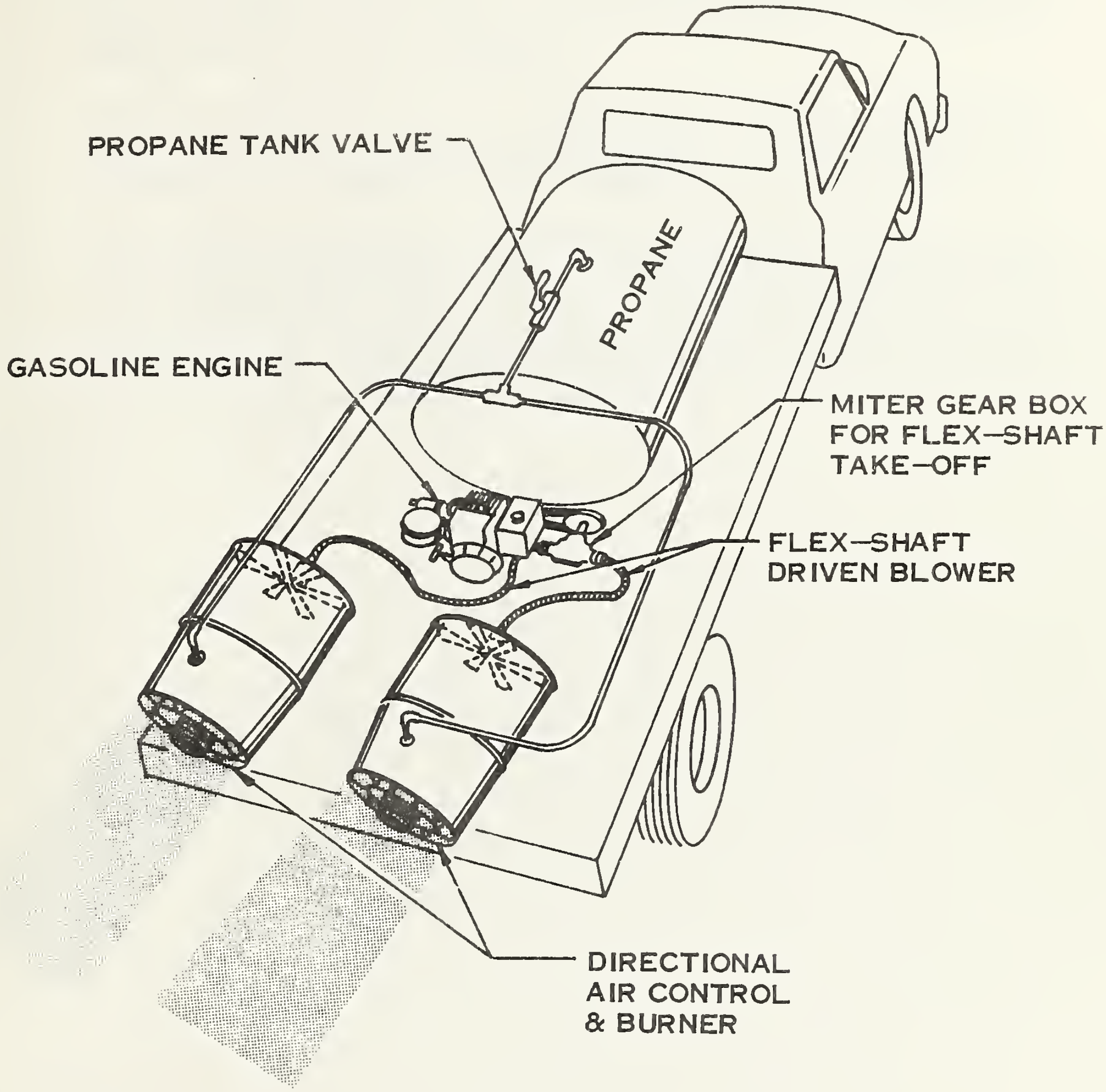

FIG. 3 — SAGEBRUSH THERMAL TREATMENT EQUIPMENT
(HIGH AIR VOLUME—LOW AIR VELOCITY)

CONCLUSIONS

1. Although further work is needed, initial tests suggest that sagebrush can be killed with air heated to 250° F. or more.

2. Moving large volumes of hot air at high velocities through sagebrush canopies appears to be an effective method of reaching all of the plants in the treatment area. Percent kill may be very high with this form of treatment.

3. Thermal treatment can be used safely during periods of high fire danger as well as during the early spring. Further evaluation is necessary to determine the best conditions for treatment.

4. Heat treatment appears to have several desirable effects on range plants that grow in association with sagebrush. The grasses and forbs treated showed no ill effects. Conifers appear to be very susceptible to heat and, if small enough, could be eradicated along with sagebrush. Resprouting in browse species can be encouraged with the same heat treatment method.

RECOMMENDATIONS

While still in the experimental stage, the concept of heat treatment appears to be very promising. If equipment can be perfected to make the method economically feasible, the rangeland manager will have a brush control system that is safe and clean. We recommend that this project be continued.

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